

## Appendix C

# Harmful Properties of Biological Agents

### WARFARE AGENTS

#### Bacteria

Bacteria are microscopic, one-celled, plant-like organisms that range from 0.1 to 10 microns in diameter. They can be classified by shape as bacilli (rod), cocci (spherical), and spirilla (spiral). Bacteria are widely distributed in nature and can grow on artificial materials in the absence of other living cells.

Among the bacteria that are considered the most likely candidates for use as biological warfare agents are *Bacillus anthracis* (anthrax), *Vibrio cholera* (cholera), *Yersinia pestis* (plague), *Francisella tularensis* (tularemia [rabbit fever or deer-fly fever]), and *Brucellosis suis* (brucellosis or undulant fever). Many other species are less dramatic but still pathogenic, such as *Salmonella typhimurium* (gastroenteritis, known as food poisoning), *Staphylococcus aureus*, and *Shingellar dysenteriae* (dysentery). Some agents usually affect animals but can be transmitted to humans with severe effects. Examples include *Burkhoderia mallei* (glanders) and *Burkhoderia pseudomallei* (melioidosis).

#### Rickettsia

Rickettsia are intracellular microscopic organisms intermediate between bacteria and viruses. They are oblong and vary in size from 0.3 to

0.5 microns in length and 0.3 micron in width. Like viruses, rickettsia cannot reproduce outside of a living organism. Rickettsia that are likely candidates for warfare agents are *Coxiella burnetti*, which causes Q fever and a chronic endocarditis; *Rickettsia prowasecki*, the causative agent of epidemic typhus; and *Rickettsia rickettsii*, the causative agent of Rocky Mountain spotted fever. Table C-1 provides a summary of the disease, likely transmission pathway, lethality, and infectivity associated with selected rickettsia agents.

### **Viruses**

A virus is a microscopic organism consisting mainly of a nucleic acid in a protein coat. Viruses are shaped like rods or spheres and range in size from about 0.01 to 0.3 micron. Viruses cannot multiply on their own, but inside a living cell they become active organisms that can multiply. The viruses considered for potential use in warfare include the Ebola virus, Hanta virus, Venezuelan equine encephalitis virus, yellow fever virus, Rift Valley fever virus, the Junin virus (Argentine hemorrhagic fever), the variola virus (smallpox), and the Dengue fever virus. Table C-1 provides a summary of the disease, transmission, pathway, and lethality associated with selected viral agents. Infectivity is not currently available for most viruses. Many are transmitted by ticks and mosquitoes. Others are transferred by human contact.

### **Biological Toxins**

Biological toxins are harmful chemical compounds produced by living organisms. Two toxins commonly associated with biological warfare are *Botulinum* and *Clostridium perfringens*. *Botulinum*, which is extremely potent, causes respiratory paralysis; the victim suffers from asphyxia. *Clostridium perfringens* causes gas gangrene in which extremities "go necrotic" by slowly suffocating them. Table C-2 provides a summary of the sources, lethality, and required detection capability for selected toxins.

### **Genetically Altered Organisms**

The last group of organisms that are used, or could be used, for warfare are genetically altered organisms. A group planning to develop a genetically altered organism would most likely aim for a more virulent or less treatable mutant of one of the agents described above. A toxin or substance created or acquired through recombinant technology would also be included in this category.

TABLE C-1 Exposure Factors for Selected Biological Warfare Agents

Agent	Disease	Transmission	Lethality	Infectivity	Required Detection Capability <sup>a</sup>
<b>Bacteria</b>					
<i>Bacillus anthracis</i>	Anthrax	Spores in aerosol	High ~ 100%	10,000 organisms	5,000 org/m <sup>3</sup> air
	Cholera	Food and water			
		Aerosol	Low with treatment	1 million organisms	500,000 org/L water
<i>Yersinia pestis</i>	Pneumonic plague	Aerosol inhalation	High unless treated	< 100 organisms	50 org/m <sup>3</sup> air
	Tularemia (rabbit fever)	Aerosol inhalation	Moderate	1 to 50 organisms	< 25 org/m <sup>3</sup> air
<i>Francisella tularensis</i>	Dysentery	Inhalation and ingestion	Moderate	10 to 100 organisms	25 org/m <sup>3</sup> air
					25 org/L water
<i>Shigelladysenteriae</i>					
<b>Rickettsia</b>					
<i>Coxiella burnetii</i>	Q fever	Aerosol inhalation	Very low	10 organisms	5 org/m <sup>3</sup> air
		Food			< 5 org/kg food
<i>Rickettsia rickettsii</i>	Rocky Mountain spotted fever	Vectors	Low	N/A	N/A

<b>Viruses</b>					
Ebola virus	Ebola	Direct contact	High for Zaire strain	N/A	
Venezuelan Equine Encephalitis (VEE) virus	Encephalitis	Aerosol Vectors	Low	N/A	
Yellow fever virus	Yellow fever	Vector/tick	Low	N/A	
Rift Valley fever virus	Rift Valley fever	Vector/ mosquito	Low	N/A	
Variola virus	Smallpox	Aerosol	High to moderate	N/A	
Hanta virus	Hanta	Aerosol	43% in U.S.	N/A	
Dengue fever	Dengue fever	Aedes mosquito	Low to moderate	N/A	

<sup>a</sup> These numbers were calculated by dividing the infectivity level by  $2 \text{ m}^3$  (the amount of air assumed to be breathed in two hours by an active adult) or by  $2 \text{ L}$ , the amount of water consumed during a day.

Source: Boyle, 1998.

TABLE C-2 Characteristics of Selected Biological Toxins

Source	Toxin	LD <sub>50</sub> (µG/kg)	Required Detection Capability <sup>a</sup>	Notes
<b>Bacteria</b>				
<i>Clostridium botulinum</i>	Botulinum A, B, C, D, E	~0.02 (inhalation) 1 (oral)	0.1 mg/m <sup>3</sup> 0.02 mg/L (water or food)	Among the most potent toxins known. Delayed lethality. Persists in food and water. Breaks down within 12 hours in air.
<i>Clostridium perfringens</i>	Gangrene-causing enzyme	0.1 to 5	0.3 mg/m <sup>3</sup>	Delayed action. Low mortality, but very debilitating.
<i>Clostridium tetani</i>	Tetanus toxin	~3	N/A	Delayed action. Relatively unstable and heat sensitive.
<i>Corynebacterium diphtheriae</i>	Diphtheria toxin	0.03	N/A	Lethal. Rapid acting.
<i>Staphylococcus aureus</i>	Staphylococcus enterotoxin A, B, C, D, E (Toxicity is for type B)	0.4 (aerosol ED <sub>50</sub> ) 20 (aerosol LD <sub>50</sub> ) 0.3 (oral ED <sub>50</sub> ) 3 mg/m <sup>3</sup>	0.058 mg/m <sup>3</sup>	Symptoms persist for up to 24-48 hours. Severely incapacitating. Can be lethal. Large-scale production feasible. Very stable.
<b>Dinoflagellates</b>				
Gonyaulax tamarensis, Gonyaulax catenella, and related species	Saxitoxin (shellfish poison)	1 (aerosol inhalation) 7 (oral)	0.01 mg/m <sup>3</sup> (air) 0.2 mg/L	Lethal. Rapid acting. Soluble in water. Relatively persistent.
Takifugu poecilonotus	Tetrodotoxin	1.5 to 3 (inhalation) 30 (oral)	0.3 mg/m <sup>3</sup> (air) 0.7 mg/L	Lethal. Rapid acting. Stable.

<b>Algae</b>	Anacystis species, Anabaena flos-aquae aeruginosa, Microcystis, cyanea	170 to 250 (IP) <sup>b</sup> 5,000 (oral) 2,100 (dermal) 25 to 100 (IP) <sup>b</sup> ~2 mg/L (water)	100 mg/L/kg (water or food) ~10 mg/m <sup>3</sup> (air) ~2 mg/L (water)	Very fast death factor. Very rapid acting. Lethal, rapid acting. Fast death factor.
<b>Fungi</b>	Fusarium species	25 to 500 (inhalation) 1,600 (oral)	40 mg/m <sup>3</sup> (air) 40 mg/L	Nonlethal, delayed effects. Inhalation, ingestion, dermal. Very stable. Small repeated doses are cumulative.
<b>Plants</b>	Ricinus communis	1,000	150 mg/m <sup>3</sup> (air) 20 mg/L (water)	Lethal, delayed action. Easily produced. Persistent.
<b>Animals</b>	Palythoa (soft corals) Conus geographus Conus magnus fish-hunting cone snails) Phyllobates aurotaenia and Phyllobates terribilis (Columbian frog)	Palytoxin 0.08 to 0.4  Conotoxins 3 to 6  Batrachotoxin 0.1 to 0.2	0.035 mg/m <sup>3</sup> (air) 0.006 mg/L (water) ~0.6 mg/m <sup>3</sup> (air) ~0.1 mg/L (water)  0.015 mg/m <sup>3</sup> (air)	Lethal and rapid acting. Stable. Water soluble. Highly stable. Can be used as aerosols. Easily synthesized.  Rapid acting and lethal. Very stable. Can be synthesized.

<sup>a</sup> Assumes 70-kg adult breathing at a rate of 0.016 m<sup>3</sup>/min for 30 minutes for air or the ingestion of 3 L water or 3 kg food by a 70-kg adult

<sup>b</sup> IP refers to intraperitoneal injection dose to mice.

Source: Boyle, 1998.

**REFERENCE**

- Boyle, R.E. 1998. Biological Warfare: A Historical Perspective. Contract No. LG-1597. Albuquerque, N.M.: Sandia National Laboratories.